A Juicy Investigation

CONTENT AREAS

- **Math**
  volume, weight, ratios

OBJECTIVES

Students will…

- gain an understanding of the waste generated by various packaging that is commonly used
- calculate the ratio of packaging weight versus actual product
- use the recycling rate to determine the amount of packaging that might go to a waste facility
- project amounts of waste generated over a period of time
- think of other factors that should be considered in packaging
- support a position statement

MATERIALS

Per groups of three or four students

- calculator
- balance that measures in ounces (or a conversion chart)
- Orange Juice Packaging Analysis Worksheet
- 64 or 46 oz. orange juice can
- 6 oz. orange juice can
- paperboard can of frozen orange juice concentrate
- juice box (aseptic package)
- aseptic package (juice box) of juice concentrate
- 64 oz. coated paper orange juice carton
- glass orange juice jar
- 2 plastic jugs (#2 HDPE colored, #2 HDPE uncolored)
- minisip juice pouches with outer paperboard box (if available in your area)
- 10 oranges with juice removed and the peel, pulp, and seeds in a plastic bag
  (Retain the juice and measure its volume in fluid ounces for use in calculations.)
  Note: *All containers must be empty. Also, it is more important to have a variety of juice containers than to have all orange juice containers. Any fruit juice will do.*

TIME

Two periods
45 minutes each

On a daily basis, we use products that have been packaged–cereal in boxes, toothpaste in tubes, vegetables in cans, shampoo in plastic bottles. In this activity, students investigate one product they are likely to encounter in the morning before they leave for school–orange juice. Even in its natural state, it comes "packaged". This activity allows students to calculate the amount of product they get for each ounce of packaging material. From their information, students see how packaging can be measured, how widely packaging varies in familiar products such as orange juice and hopefully, how they can make more informed purchasing decisions.

PROCEDURE

1. As part of a discussion or writing activity, ask students to list as many types of packaging as they can think of for orange juice or other types of fruit juice.

2. Tell students they are going to compare many of these types of packaging to see which contributes most to solid waste. Ask, "What would be a fair way to compare each of these packages?" Lead students to the idea of finding out how much juice is delivered for each ounce of packaging. (It's not fair just to weigh the package, since different containers deliver different amounts of juice.)

3. Divide the class into groups of three or four students each. Give each group at least one or two containers. Although you may not have all the juice containers, it is important that you have the common ones: paperboard cartons, plastic jugs, paperboard frozen concentrate cans, juice boxes and fresh oranges. If you don't have all the containers, obtain a few of each kind so groups can work without waiting.

4. Give each group a copy of the student worksheet. Ask students to write down a hypothesis about which container provides the most orange juice for each ounce of container. Point out that an ounce is a measure of weight–a fluid ounce is a measure of volume. For this activity, students will compare fluid ounces of orange juice (volume) to ounces of packaging (weight).

5. Tell students to follow the instructions on the worksheet as they weigh the various containers, make their calculations and record data. Be available to answer questions and solve problems as students complete their worksheet data tables.

To help things along, you might want to make an overhead of the Student Handout on page 70 and walk your students through an example.

QUESTIONS

When students have completed their worksheets, have them answer the following questions in writing or discussion:

a. Which product provides the most juice for the least packaging?

b. How does this change when recycling rates are considered?

c. What are other waste and energy factors that should be considered when evaluating these products?(Consider factors such as refrigeration and freezing, energy needed to process various juices, shipping, amount of shipping packaging, size of product.)

d. Which packaging would you choose? Support your answer with evidence.

e. Were your hypotheses concerning orange juice containers correct?

EXTENSIONS

1. Construct a bar graph showing the amount of orange juice provided by each ounce of packaging. This is the information in Column D of Data Table 1. Students could also construct a bar graph that shows the amount of waste for each type of container. This information is found in Column E of Data Table 2.

2. Name other goods that come packaged in many different ways, such as laundry detergent. Do an analysis similar to the one you did for orange juice and present your findings to the class.

3. Some packaging is unpopular with consumers, even though it's the best choice in terms of source reduction. What are some products this may be true about, and what may be some of the reasons consumers choose them?

4. Research the history of water packaging. Since prehistoric times, humans have needed to carry and store water. Carrying water allowed hunters, farmers and nomads to venture away from water sources. How has water storage evolved? How is it stored and delivered in your community? Do you get water from a reservoir or well? What form does packaged water come in your area?

5. Determine the cost of juice delivered per ounce of packaging. Are the most efficient packages the best sellers? What does this tell you about the value of convenience to most people?

DID YOU KNOW?

Students may think that fresh orange juice would be the best choice overall. They may be interested to know that if the 9.3 million tons of citrus fruit produced in Florida were shipped fresh to consumers, 4.8 million tons of waste would need to be disposed of by sanitation workers. Instead, only about 1 million tons is produced. The parts of the fruit that can't be eaten stay in Florida, where they are made into animal feed and other by-products.[1]

REFERENCE

1. Kelsey, Robert, *Packaging in Today's Society,* Lancaster: Technomonic Publishing Company, 1989, p.32.

Teacher's Notes

Here are reference numbers for various packaging types. You'll note that concentrates are by far the most efficient way to package juice, followed by HDPE (#2) plastic and paper cartons. Glass is relatively inefficient, and 10 fresh oranges are the most inefficient of all!

Juice Packaging Comparison

	Fl. oz. of Juice	Oz. of Packaging	Fl.oz.of juice/ Oz. of Packaging	% Product to % Packaging*
Paper carton	64.0	2.3	27.8	97/3
Glass bottle	32.0	15.7	2.0	67/33
Steel can	46.0	5.7	8.1	89/11
Juice box	8.5	0.4	21.3	95/5
Half-gallon HDPE bottle	64.0	1.7	37.6	97/3
Mini-sip pouches/box (Capri-Sun)	67.8	6.7	10.1	91/9
Concentrate (juice box)	46.0	0.5	92.0	99/1
Concentrate (frozen, paperboard)	48.0	1.1	43.6	98/2
10 oranges	27.0	41 .0	0.7	40/60

**Numbers are approximate, because the weight of different juices will affect the ratio.*

Orange Juice Packaging Analysis Worksheet

Data Table 1

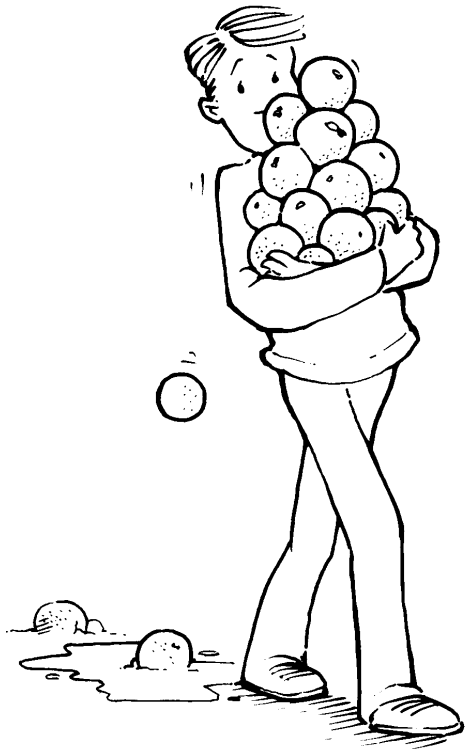
A Package or Product	B Pkg. Wt. in Oz.	C Juice*Amount in Fluid Oz.	D Fluid Oz. of Juice per Oz. of Pkg.	E Wt. per Gal. of Juice (128 x D)	F Wt. per 100 Gal. in Oz. (E x 100)	G Pkg. Wt. per 100 Gal. in Lbs. (F/16)

**For concentrates, use ready to drink (reconstituted) fluid ounces.*

Data Table 2

A Package or Product	B Recycle Rate (%)	C Pkg. Wt. per 100 gal. in lbs.	D Amount Recycled in lbs. (BxC)	E Amount of Waste to Waste Facility in lbs. (C-D)

Orange Juice Packaging Analysis Worksheet



DIRECTIONS

1. Develop a hypothesis about which container provides the most orange juice for the least amount of packaging weight.

2. Now make a hypothesis about which container, after recycling, contributes most to the solid waste problem.

3. For each juice container, starting with the one that has been given to you, work as a group to complete the following calculations and record the information in Data Table 1. Remember: In this activity, you are comparing fluid ounces of orange juice (volume) to ounces of packaging (weight).

DATA TABLE 1

Here's a guide to the information needed in each column of Data Table 1:

Column A: Note the type of package you are examining.

Column B: Weigh the package on the scale. Note how many ounces it weighs.

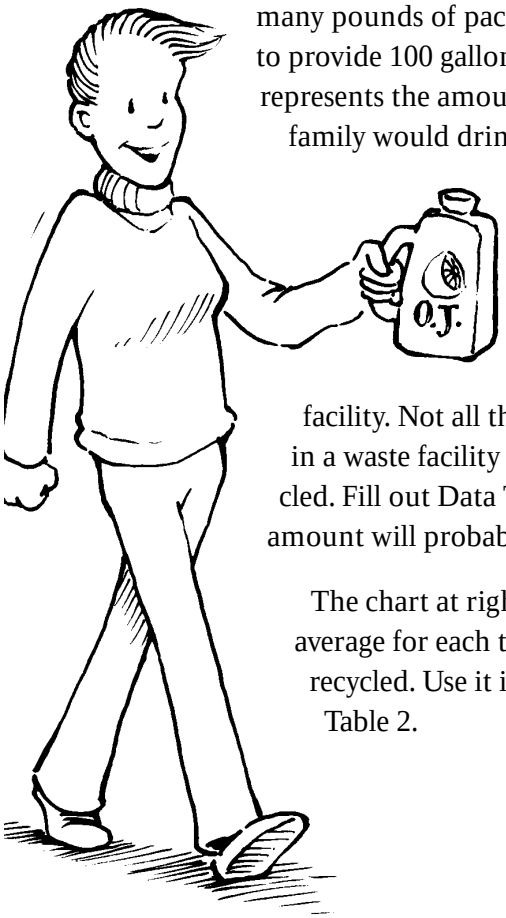
Column C: Note the number of fluid ounces of juice the package contains or provides. For the concentrate can, note the amount of juice the concentrate makes when water is added, not the amount of concentrate in the package. Return the package.

Column D: Calculate how many fluid ounces of juice are provided for each ounce of packaging. Divide the number of fluid ounces provided (answer in Column C) by the weight of the package (answer in Column B).

Column E: Calculate what the weight of this type of packaging would be if you needed one gallon of juice. Multiply the answer in Column D by 128 (1 gallon = 128 fluid ounces).

Column F: Calculate what the weight of this type of package would be if you needed 100 gallons of juice. Multiply the answer in Column E by 100.

Column G: The answer in Column F measures the weight of packaging material per 100 gallons of juice in ounces. To find out how many pounds of packaging material this is equivalent to, divide the answer in Column F by 16(1 lb. = 16 oz.).



4. In the last column, you found out how many pounds of packaging material it takes to provide 100 gallons of orange juice. That represents the amount of orange juice a family would drink in a year if it drank about two gallons a week. Now let's see how those packaging figures translate into waste being sent to a waste facility. Not all the packaging ends up in a waste facility because some is recycled. Fill out Data Table 2 to see what amount will probably end up as waste.

The chart at right gives the national average for each type of material that is recycled. Use it in answering Data Table 2.

Recycling (Recovery) Rates for Various Packaging Materials

Steel cans	53%
Aluminum cans	65%
Glass containers	29%
Frozen concentrate can	0%
Paperboard carton	1%
HDPE #2 colorless plastic bottles	26%
HDPE #2 colored plastic	11%
PET #1 plastic bottle *	8%
Aseptic (juice) boxes	1%
Mini-sip pouches	0%

**Does not include PET soft drink bottles, which have a recovery rate of 49%.*
Source: Resource Recycling magazine, July 1995

DATA TABLE 2

Here's a guide to the information needed in each column of Data Table 2:

Column A: Note the type of package.

Column B: Find the recycling rate for the type of packaging material.

Column C: Record the weight of the packaging, in pounds, per 100 gallons of juice. (Data Table 1, Column G).

Column D: Figure how many pounds of this packaging can be expected to be recycled. Multiply Column B by Column C.

Column E: Calculate how many pounds of this packaging can be expected to end up at a waste facility. Subtract Column D from Column C.